



NASA

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**Use of Satellites and Integrated
Technologies for Humanitarian
Purposes
Varese, Italy**

**The Shuttle Radar
Topography Mission:
“Low resolution”
Digital Topography
of the World**

September 19, 2000

This research was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration.



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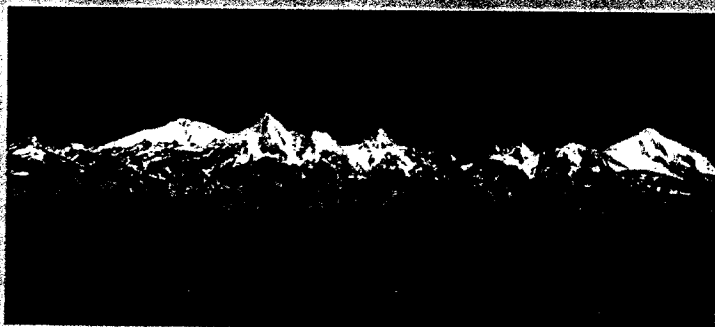
The SRTM Challenge: Bits to Beauty

- **Process from raw data**

In-board: 1 0 1 1 0 0

Out-board: 1 0 0 1 0 1 ..

- **To elevations**

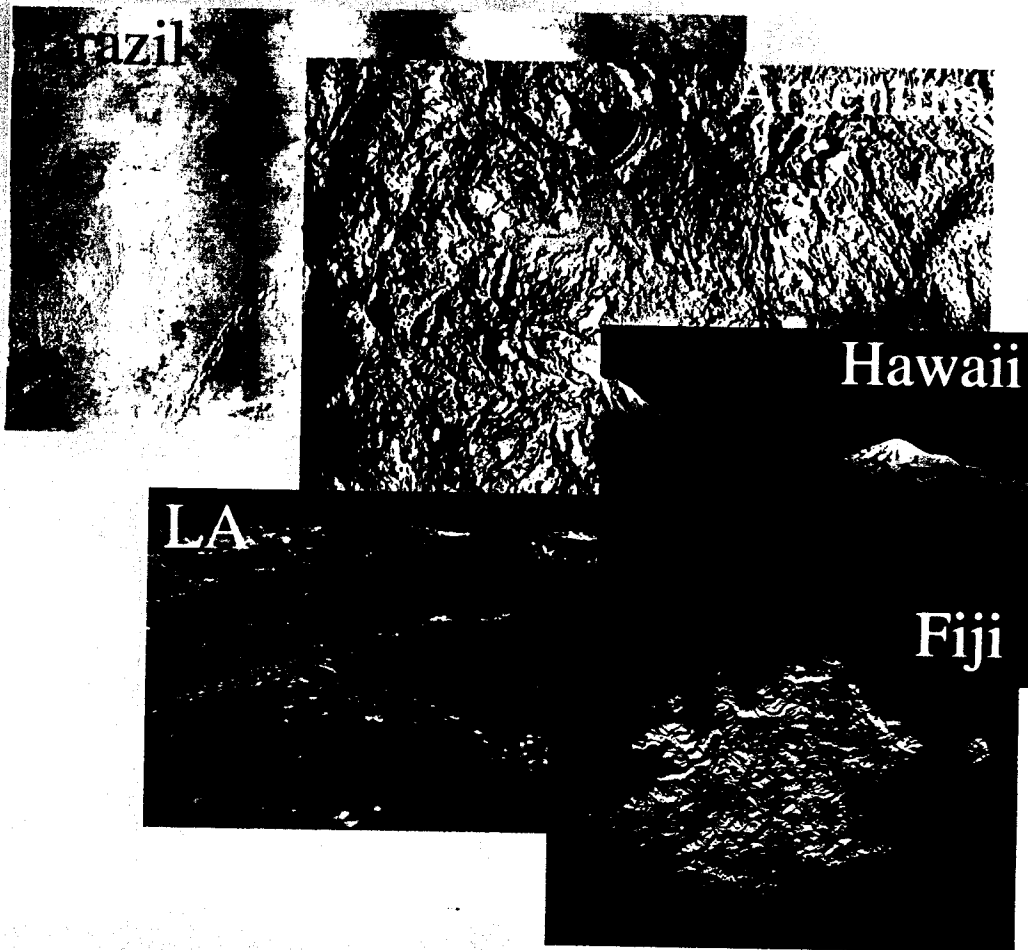


- **For the world, twice+,
in two years**



Mission Processing: Feb 11-22, 2000

- Generated 0.5 M km² of topography and imagery during the mission
- Exercised Beam-to-beam mosaicking, creating 225 km swaths
- Helped verify interferometer system performance
 - Downlinked datatake every 40 minutes

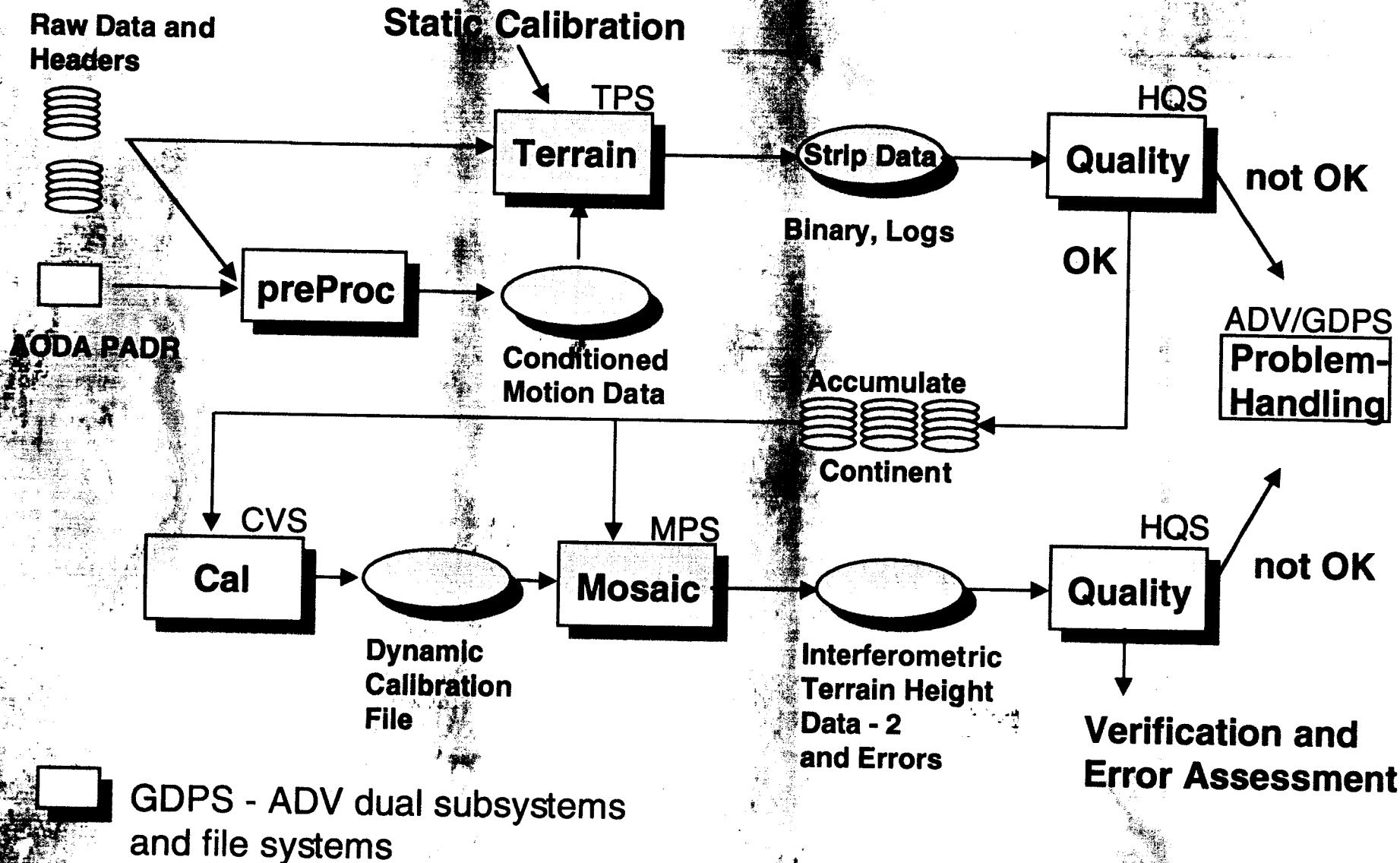




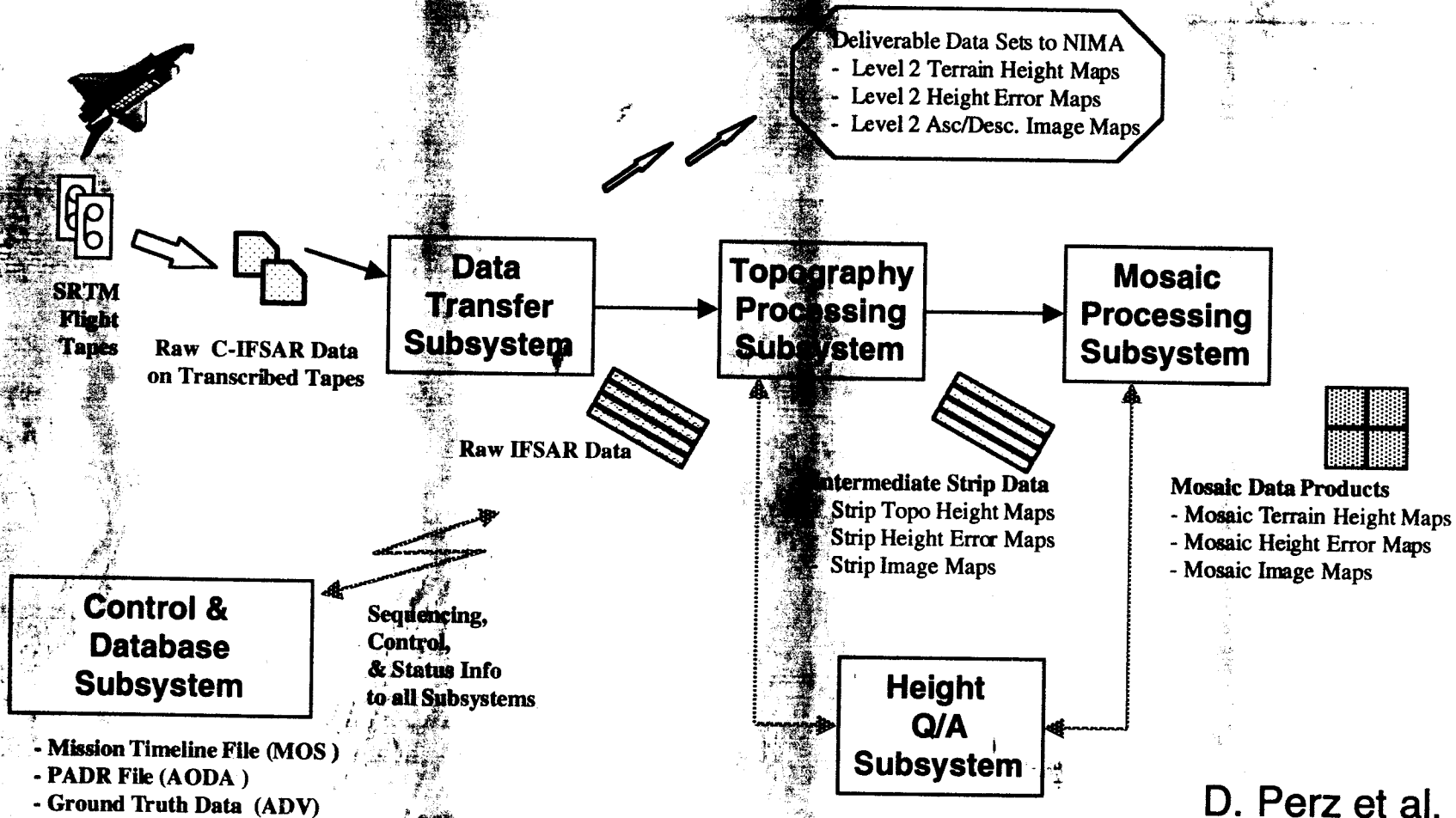
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SRTM Algorithmic Flow



SRTM Ground Data Processing System



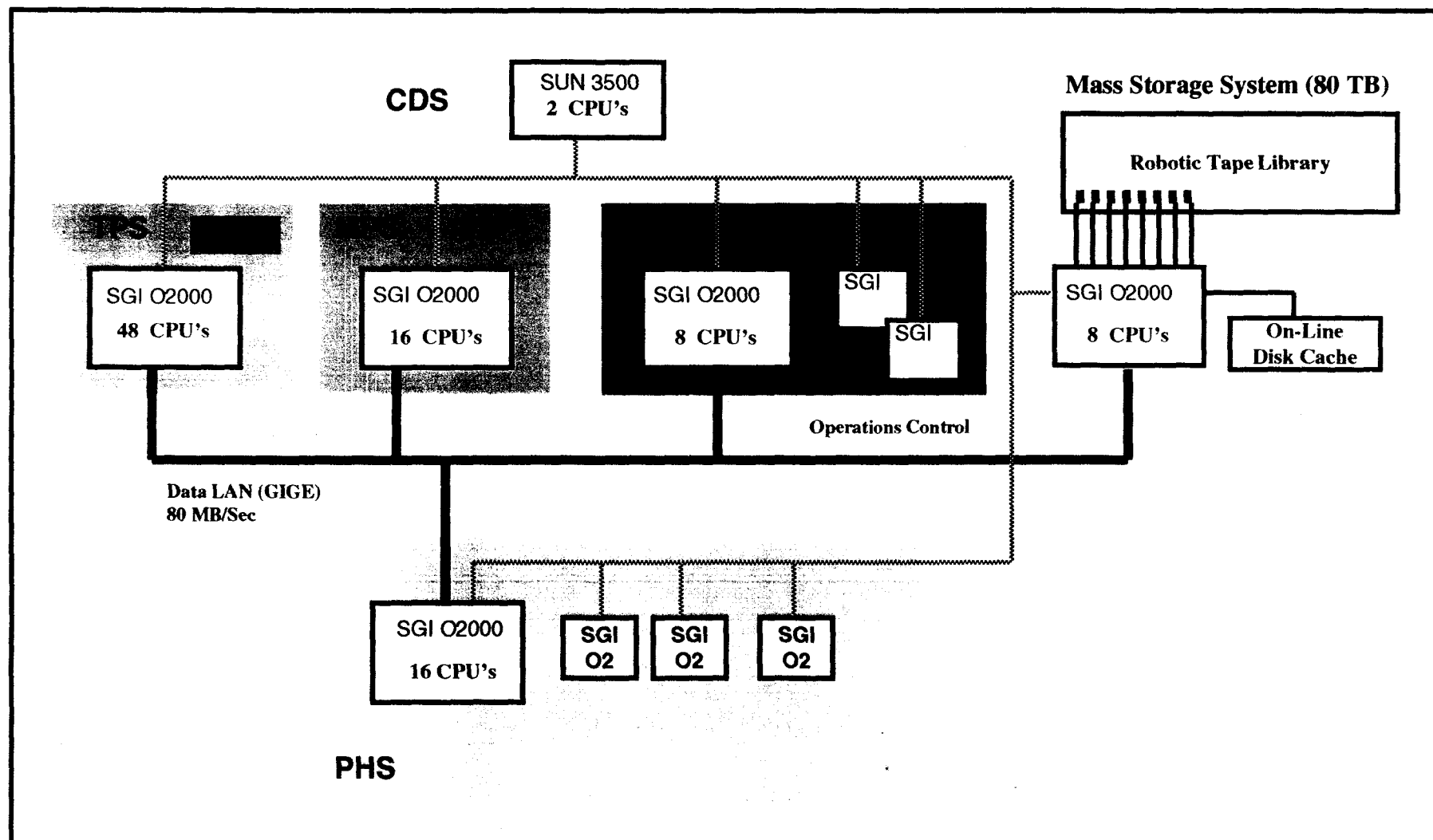
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SRTM Production System Architecture



Pre-production Calibration Activities

- Corner Reflector Arrays and Short Ocean Data Takes
 - Absolute and relative channel delays
 - Timing constants
 - Roll constants
- Long Ocean Data Takes
 - Systematic trends
 - Radar state changes

CA



Oz



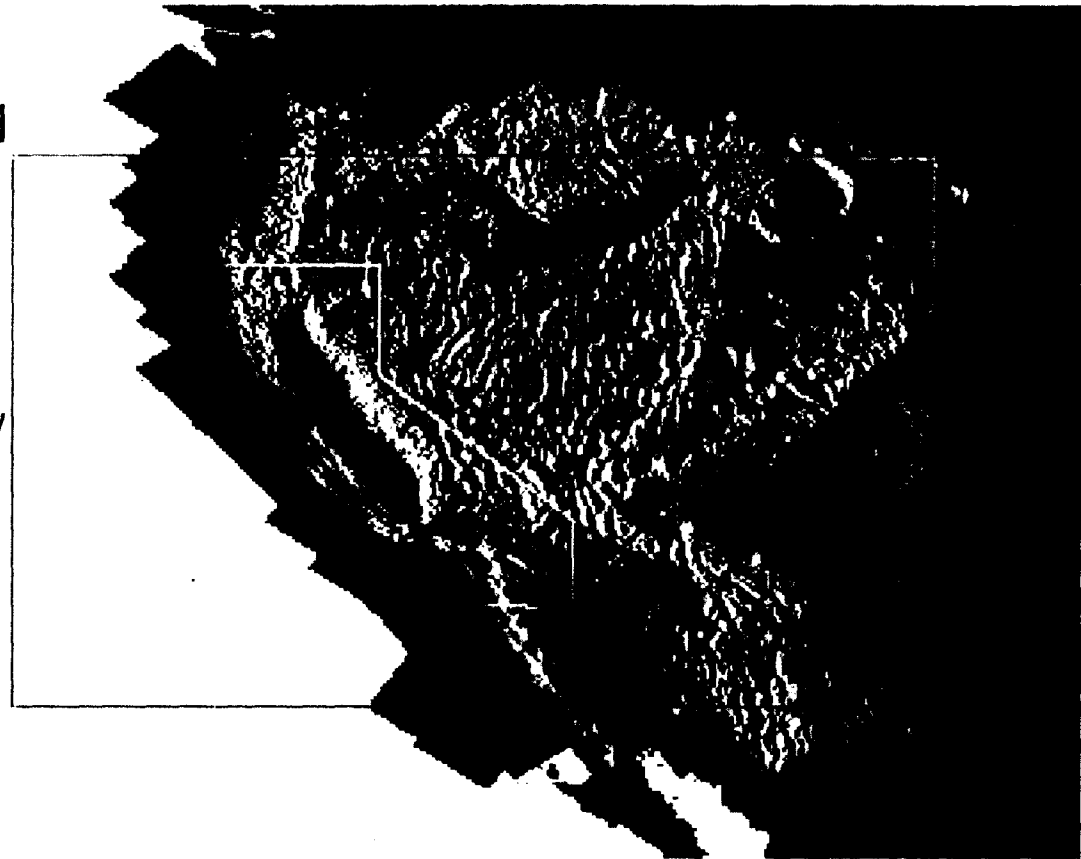


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Pre-production Sample Data Sets

- NIMA Sites
- PI Science Sites
 - Funded NASA PI requests to be prioritized
- Large Scale DEM Mosaic
 - Much of Western US, but complete ascending/descending coverage only in California
 - Accuracy approaching final product accuracy
 - Availability tied to delivery of final motion solution



Some SRTM Products

- Mosaicked Terrain Height in DTED-2 Format
 - 1° x 1° cells
 - Equiangular projection
 - 16 bit fixed point in decimeters
- Mosaicked Terrain Height Error in NITF Format
 - Identical cell pixelation and projection to terrain height
 - Quantization and scale TBD
- Mosaicked Ascending and Descending Image in NITF Format
 - “Nearest to 45 degrees” priority for multiple observations (not averaging of brightnesses)
 - Identical cell pixelation and projection to terrain height
 - Quantization, compression, and scale TBD

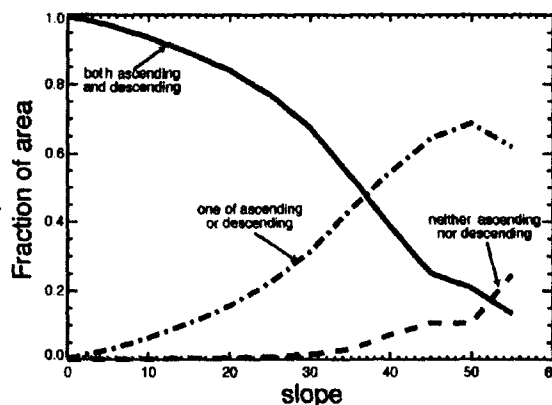
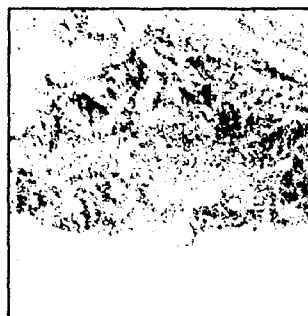
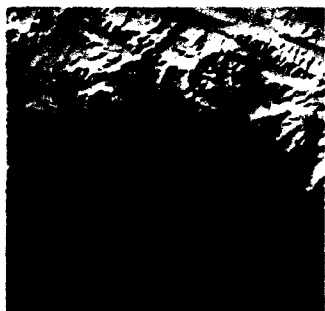


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Expected Coverage (or Better)

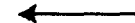
Simulation of layover and shadow
San Gabriel mountains



World slope distribution



~~slope
resolution
adjustment~~



Assumes perfect
unwrapping...

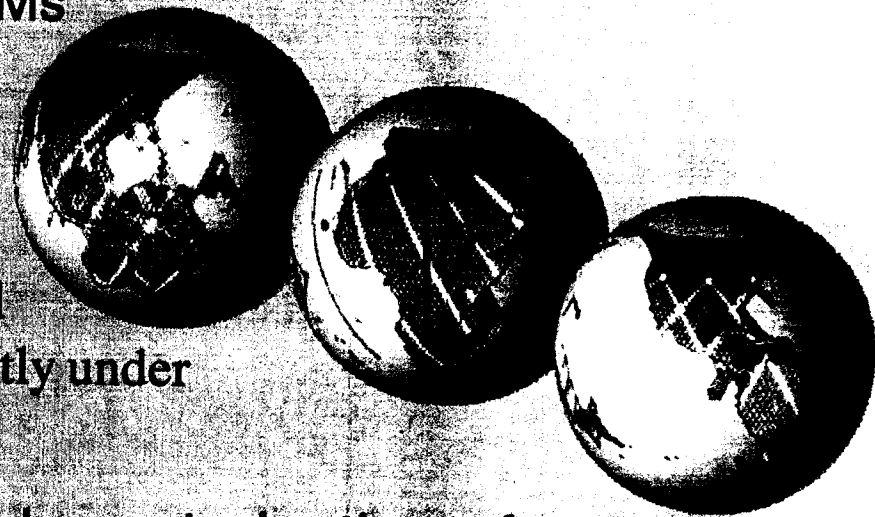


	world >20° S.G.		
missing	0.1	1.0	0.5%
covered	2.9	21.3	11.3%
only once			
covered	97.0	77.7	88.2%
twice			

SRTM Product Verification

- Verification of the height product takes advantage of
 - accurate control points, globally distributed
 - several fine-accuracy DEMs
 - Kinematic GPS surveys

KGPS transects in Asia and Middle East needed, currently under investigation by NIMA



- KGPS and DEMs allow characterization of spatial error signature
- World's first systematic topographic error model, continent by continent

SRTM Interferometric Processing

Why does it take 2 years?

- Ground system still under development through 2000 per project funding profile
- Additional products recently added to nominal plan increase development time
- Interferometric cartography is exacting. The shuttle interferometer system is dynamically complex. It takes time to sort out all contributors to error.
 - Shuttle attitude, boom metrology, radar relative phases must be known for each time instant to *microradians, millimeters, and degrees*.
 - Map to be accurate to ~15m absolute on a body of dimension 40,000,000 m circumference. (3×10^7)
- The radar interferometer is a complex system.
 - Of order 15 distinct radar states, each requiring phase and possibly baseline calibration

More of why it takes 2 years to process SRTM data

- One year of production is quite fast for 1.1 Terabytes of raw data
 - ~14,000 $1^{\circ} \times 1^{\circ}$ cells, each with ascending/ descending passes
 - 40 cells per day, each with Q/A, estimated errors and other statistics
 - Continental scale bundle adjustment for self-consistency and reduced systematic errors
- One year of production contains margin for reprocessing
- There are two global maps to produce, ascending and descending
- Continents are phased deliveries over the year
- SRTM will complete a job that other technologies could not in many more years



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SRTM Year 2000 Digital World Topography



Coming to databases near you in 2002...